Oral health is influenced by oral microbial flora, which are concentrated in dental plaque. Dental plaque provides a microhabitat for organisms and an opportunity for adherence of the organisms to either the tooth surface or other microorganisms. In critically ill patients, potential pathogens can be cultured from the oral cavity. These microorganisms in the mouth can translocate and colonize the lung, resulting in ventilator-associated pneumonia. The importance of oral care in the intensive care unit has been noted in the literature, but little research is available on mechanical or pharmacological approaches to reducing oral microbial flora via oral care in critically ill adults. Most research in oral care has been directed toward patients’ comfort; the microbiological and physiological effects of tooth brushing in the intensive care unit have not been reported. Although 2 studies indicated reductions in rates of ventilator-associated pneumonia in cardiac surgery patients who received chlorhexidine before intubation and postoperatively, the effects of chlorhexidine in reducing ventilator-associated pneumonia in other populations of critically ill patients or its effect when treatment with the agent initiated after intubation have not been reported. In addition, no evaluation of the effectiveness of pharmacological and mechanical interventions relative to each other or in combination has been published. Additional studies are needed to develop and test best practices for oral care in critically ill patients. (American Journal of Critical Care. 2004;13:25-34)

Oral health has a profound effect on general health. Oropharyngeal colonization is associated with several systemic diseases, including cardiovascular disease, chronic obstructive pulmonary disease, endocarditis, and bacteremia. In the intensive care unit (ICU), interest in the relationship of oral health to systemic disease has focused on the development of ventilator-associated pneumonia (VAP). Bacterial colonization of the oropharynx is an important risk factor for VAP. Oral health, which includes accumulation of dental plaque, oral microbial flora, and local oral immunity, influences the number of organisms, including pathogens that may cause VAP, in the oral cavity. Thus, oral care interventions that prevent the accumulation of plaque and stimulate local oral immunity during the early period of hospitalization may reduce development of VAP.

Essentially 2 ways exist to remove dental plaque and associated microbes: mechanical interventions such as tooth brushing and rinsing of the oral cavity and direct pharmacological intervention with antimicrobial agents. The importance of oral care in the ICU has been noted, but no evidence-based oral care protocols for the ICU have been reported.

In this article, we describe oral health in critically ill patients, review existing research on the relationship of oral health to nosocomial pneumonia in the ICU, and discuss the state of the science of oral care interventions in ICU patients.
Oral Health and Critical Illness

Oral health is influenced by dental plaque, the oral microbial flora, and oral immunity. Patients admitted to the ICU may have preexisting poor oral health. The Surgeon General’s report on oral health in America identified a “silent epidemic” of dental and oral disease in the general population. Persons with the worst oral health include the poor and members of racial and ethnic minorities. Patients’ oral health may be compromised by medical conditions or treatments, ICU equipment, and the patients’ inability to attend to their own oral care. In healthy adults, the predominant aerobic oral organisms are viridans streptococci, but the flora of critically ill patients changes to predominantly gram-negative organisms, constituting a more virulent flora that includes potential causative agents of VAP, such as Staphylococcus aureus, Streptococcus pneumoniae, Acinetobacter baumannii, Hemophilus influenzae, and Pseudomonas aeruginosa. Oral immunity provides mechanisms to control microbial growth in the oropharynx.

Dental Plaque

Initial colonization of the tooth surfaces by bacteria occurs in childhood at the time of eruption of the first tooth, and in a healthy person, the number and species of organisms in dental plaque remain relatively constant throughout life. The predominant aerobic species are the viridans streptococci. Microbial flora are concentrated in dental plaque, which is a complex environmental niche of interdependent microorganisms embedded in bacterial and salivary products. Dental plaque is a biofilm found on tooth surfaces that provides a microhabitat for microorganisms. Plaque provides opportunity for adherence of the organisms to either the tooth surface or other microorganisms, and plaque accumulation is enhanced by bacterial aggregation between and among microbial species. Calculus occurs when minerals are deposited intracellularly and extracellularly in dental plaque; this calcified material is resistant to removal. Oral debris is loose material (eg, food particles) that influences the components of microbial flora, in part by providing food sources for the organisms present in plaque. Dental plaque can be removed from the mouth via mechanical or pharmacological interventions.

Dental plaque may serve as a reservoir for pathogens in patients with poor oral hygiene, and dental plaque of patients in the ICU, unlike that of healthy persons, can be colonized by potential respiratory pathogens such as methicillin-resistant S aureus and P aeruginosa. In a classic study of 20 acutely ill patients requiring prolonged orotracheal intubation, Schwartz et al determined the source and progression of gram-negative organisms colonizing the trachea. All patients had gram-negative organisms in the trachea by day 3 after intubation. Fourrier et al examined the relationship between dental plaque, oral colonization, and nosocomial infections in a descriptive study of 57 ICU patients. For each patient, quantitative cultures of dental plaque and tracheal aspirates, assessment of dental plaque on premolars, and assessment of nosocomial infection were done at the time of admission (day 0) and every fifth day until the patient died or was discharged from the ICU. Fourrier et al found high concordance between the bacteria present in cultures of dental plaque and the bacteria present in cultures of tracheal aspirates. A nosocomial infection developed in 21 patients. Five of these infections were pneumonias (determined by recovery of pathogens from bronchoalveolar lavage fluid). In 4 of 5 patients with pneumonia, the causative organism (A baumannii in 2 patients and P aeruginosa in 2) was isolated from the patients’ dental plaque before the diagnosis of pneumonia. These studies support the hypothesis that dental plaque can serve as a reservoir for microorganisms that can cause VAP.

Oral Microbial Flora

The oropharynx of a healthy person is a microbially rich environment. Streptococcus salivarius, a viridans streptococcus that is one of the first organisms to colonize the oropharynx, can be isolated from the oropharyngeal cavity of infants as soon as 18 hours after birth. A healthy person’s oral flora remains stable over time. However, within 48 hours of admission to a hospital, the composition of the oropharyngeal flora of critically ill patients undergoes a change from the usual predominance of gram-positive streptococci and dental pathogens to predominantly gram-negative organisms, constituting a more virulent flora, including pathogens that may cause VAP.

The oral flora of critically ill adults differs from that of healthy adults and contains organisms that may cause pneumonia.

One of the most critical risk factors for nosocomial pneumonia in patients treated with mechanical ventilation is colonization of the oropharynx. Several factors increase bacterial colonization of the oropharynx in these patients. Growth of potentially
pathogenic bacteria in dental plaque provides a nidus of infection for microorganisms that can cause VAP.\textsuperscript{29,37} Endotracheal tubes provide a pathway for direct entry of bacteria from the oropharynx through an open glottis to the lower part of the respiratory tract. In addition, endotracheal tubes promote colonization by interfering with the cough reflex and the function of the mucociliary escalator and by stimulating excessive mucus secretion.\textsuperscript{34} Reducing the number of microorganisms in the mouth reduces the pool of organisms available for translocation to and colonization of the lung. Therefore, removal of organisms from the oral cavity by oral care interventions is a theoretically attractive method to reduce the risk for VAP.

One of the most critical risk factors for ventilator-associated pneumonia is microbial colonization of the oropharynx.

Bacterial colonization of the oropharynx with \textit{S. aureus}, \textit{S. pneumoniae}, or gram-negative rods (eg, \textit{A. baumannii}, \textit{H. influenzae}, and \textit{P. aeruginosa}) is positively associated with the occurrence of nosocomial pneumonia.\textsuperscript{22-25} Indeed, in individual patients with VAP, identical species of microorganisms were found in cultures of material from the oropharynx and cultures of material obtained from the lower part of the respiratory tract via fiberoptic bronchoscopy.\textsuperscript{23} Garrouste-Orgeas et al\textsuperscript{40} prospectively examined microbial colonization of the oropharynx longitudinally throughout ICU admission for 86 adults treated with mechanical ventilation; 31 cases of VAP occurred. Bacterial colonization of the oropharynx occurred in the majority of patients. Using pulsed-field gel electrophoresis, the investigators compared the chromosomal DNA identity of microorganisms in oropharyngeal samples obtained before diagnosis of VAP and in bronchial samples for each patient in whom VAP developed. Organisms isolated from the oropharynx before diagnosis of VAP were identical to the pathogen that caused VAP for that patient in 28 of 31 cases. Further, the role of oral colonization in the development of VAP is suggested by medical research\textsuperscript{42,39} that indicates that use of oral topical antibiotics directed against gram-negative organisms and fungi reduced the incidence of VAP related to those pathogens.

More recently, Cardenosa Cendrero et al\textsuperscript{40} investigated the routes of tracheal colonization in the development of VAP and found that 80 of 110 patients had tracheal colonization during the first day of mechanical ventilation. In addition, in a majority of cases (68%), colonization of the oropharynx by the pathogen that caused VAP occurred before the pneumonia was diagnosed. In a study in which we and others\textsuperscript{41} examined the effect of oral health on the development of VAP in 66 patients in a medical ICU, we found that the number of organisms present in oral cultures increased from day 1 to day 4 and remained high on day 7. In addition, each of 6 patients treated with mechanical ventilation who had a VAP-related pathogenic organism in cultures of tracheal aspirates (including \textit{S. aureus}, \textit{S. pneumoniae}, \textit{A. baumannii}, and \textit{P. aeruginosa}) also had the same species in oral cultures before or concurrent with appearance of the species in the tracheal aspirates. In summary, research findings indicate that the oral cavity is a primary source of pathogens that cause VAP.

**Oral Immunity**

Oral immunity is important because it contributes to control of the growth of microorganisms in the oral cavity. Both innate oral immunity and adaptive oral immunity are influenced by salivary flow and by immune components in the saliva.\textsuperscript{42,43} Saliva provides mechanical removal of plaque and microorganisms as it circulates in the oral cavity and also contains a variety of innate and specific immune components. The importance of the production and distribution of saliva is vividly indicated by the problems that occur in patients with Sjögren syndrome, in which autoimmune attack on the salivary glands leads to xerostomia (dry mouth). Microbial overgrowth occurs, heavy dental plaque accumulates, and rampant dental caries develop.\textsuperscript{31,42,44-46} In addition, some patients with Sjögren syndrome have an increased risk for respiratory colonization and pneumonia.\textsuperscript{47,48}

Many critically ill adults have medical equipment in place that traverses the oral or nasopharyngeal cavity, including oral airways, endotracheal tubes, and feeding tubes. Placement of these devices may keep a patient’s mouth continuously open, a situation that may contribute to xerostomia.\textsuperscript{37} Xerostomia also is enhanced by stress and anxiety,\textsuperscript{51} which generally accompany critical illness. In addition, drying of mucous membranes related to fluid imbalances can damage the membranes. Persons who are able to attend to their own activities of daily living can counteract xerostomia by frequent oral self-care and increased hydration, but such self-care activities are limited in the ICU. Thus, patients treated with mechanical ventilation often have xerostomia, which contributes to accumulation of dental plaque and reduces the distribution of salivary immune factors,
including salivary immunoglobulin A (IgA; an adaptive immune factor) and lactoferrin (an innate immune factor), in the oral cavity.42

Adaptive and innate immune components in the saliva provide defenses against microbial growth.43 Much is known about the effects of critical illness on systemic immunity, but less is known about the specific effects on oral immunity. Patients treated with mechanical ventilation are immunocompromised by virtue of their critical illness. Immunocompromise can occur in critically ill patients,52,53 in patients who have surgery,54,55 and experimentally in animals after fracture and hemorrhage.56 Although oral immunity in patients treated with mechanical ventilation has not been extensively examined, the literature on oral status in other immunocompromised populations provides direction for investigation of oral status in patients treated with mechanical ventilation.

As opportunistic pathogens, normal flora may cause a variety of infections in immunocompromised persons. Bacterial agents associated with serious infections, including S. aureus and Pseudomonas species, which are important causative agents of VAP, have been found in the oral microbial flora of immunocompromised patients.57 Immunosuppression also increases the absolute numbers of fungi and alters the oral environment in a manner that may enhance fungal infection of the oral mucous membranes. Immune mechanisms that may play a role in increased susceptibility to infection of the oral mucosa in immunocompromised persons include decreased levels of IgA and lactoferrin.

IgA is the predominant immunoglobulin in saliva.58,59 The important role of IgA in saliva in protection against respiratory pathogens is well established,28,60 and decreased IgA production is thought to increase the susceptibility to upper respiratory tract infections.61 IgA can prevent adsorption and penetration of bacteria and/or viruses into the mucosa of the upper part of the respiratory tract. The immunoglobulin is active against both gram-positive and gram-negative organisms, and recent research62 indicated that IgA in tears can inhibit adhesion of P. aeruginosa to contact lenses. Salivary IgA and saliva volume may be abnormal in patients infected with human immunodeficiency virus,63,64 and Umazume et al65 found that saliva volume and salivary IgA concentration were lower in patients with oral carcinoma than in healthy control subjects.

Innate immune mechanisms may also be important in preventing infections that have a nidus in the oral cavity. For example, nonspecific salivary components such as lactoferrin may play a defensive role.66 Lactoferrin is an iron sequestration protein thought to inhibit proliferation of microorganisms by making iron unavailable for microbial metabolism. Apolactoferrin (lactoferrin without bound iron) can have direct microbicidal effects on some species and can bind to gram-negative bacterial lipopolysaccharide.66 Lactoferrin is bactericidal against several major pathogens that can cause VAP, including S. aureus,67 P. aeruginosa,66,67 and H. influenzae.66 Addition of lactoferrin to cultures of P. aeruginosa is associated with increased sensitivity of the bacterium to antibiotics.66,67 In a study of patients receiving oral cancer therapy, Umazume et al66 found a high correlation between lactoferrin levels in saliva samples and the ability of the saliva to inhibit growth of Candida albicans in vitro.

Although markers of oral immunity, dental plaque, and xerostomia have been examined singly in other immunocompromised populations, no research has been reported on the relationship of these factors to the development of VAP in critically ill patients. Oral immunity is altered in critically ill patients; alterations in salivary flow and salivary immune components, including cortisol, neopterin, lactoferrin, and IgA, have been reported.68

**Oral Care Interventions**

The association between oral microbial flora and VAP is well documented. Because dental plaque can serve as a reservoir for microorganisms that may cause VAP, oral care regimens that improve oral health status could reduce development of VAP. Two methods are used to remove dental plaque and associated microbes: mechanical interventions (including tooth brushing and rinsing of the oral cavity) and pharmacological interventions (including use of antimicrobial agents). However, usual oral care regimens may be difficult or impossible for a critically ill patient or the patient’s caregiver to perform. Because of these limitations, removal of plaque (and its major component, microbial flora) may be inadequate.

Unfortunately, little is known about the effects of oral care interventions in critically ill patients treated with mechanical ventilation. Evidence-based protocols for oral care of such patients are not available, and oral hygiene measures are generally directed toward patients’ comfort rather than removal of microbes.69 The lack of published protocols for oral care in intubated patients has been noted.70 Definitive scientific studies relating oral care interventions to VAP have not yet been published. In a comprehensive review of evidence-based practice related to strategies to prevent VAP, Hixson et al70 noted that even though oral hygiene is considered standard nursing care, it is often neglected in critically ill patients or performed by quickly swabbing patients’ mouths. Hixson et al
called for studies evaluating the effectiveness of various methods of oral care.

**Oral care regimens that remove dental plaque could reduce the incidence of ventilator-associated pneumonia.**

**Mechanical Interventions**

Current oral care practice by nurses is not evidence based, is poorly defined and inconsistent, does not include a defined mechanical oral care component, and focuses on patients' comfort rather than on removal of plaque and microbes. Surveys of critical care nurses and other research studies indicate that in the absence of evidence-based practice guidelines, nurses provide a variety of oral interventions designed to address patients' comfort. ICU nurses may be hesitant to provide oral care to patients who are intubated because endotracheal tubes may limit access to the oral cavity. Nurses may also fear dislodging or displacing the tube or inducing bacteremia. Provision of oral care may be affected by the perception that oral care is less contributory to patients' health and well-being (or of lower priority) than other nursing interventions for critically ill patients. In research in which we participated, ICU nurses' mean rating of the priority of oral care was 53.9 on a 100-point scale.

Nurses determine what methods will be used to provide oral comfort care for each patient. Methods cited by nurses included placing a foam swab in the oral cavity without agitation, placing lemon and glycerine swabs in the oral cavity, swabbing with mouthwash or water, and brushing teeth with foam swabs. However, in a study of 66 patients receiving mechanical ventilation, the routine oral comfort care provided by nurses was not associated with a reduction in either dental plaque or VAP. Pearson found that foam swabs were less effective than tooth brushing in plaque removal over a 6-day period; the efficacy of foam swabs was dependent on user technique. However, the sample in Pearson's study consisted of only 2 healthy volunteers, who provided their own intervention. A survey distributed to the nurses in a medical respiratory ICU revealed that most nurses used a foam swab dipped in either water or mouthwash to provide mouth care to patients. No consistent intervention for mouth care was detected, and the frequency of application varied from nurse to nurse and from patient to patient. Further research indicated that nurses in medical respiratory, surgical trauma, and neurological ICUs used foam swabs to provide mouth care for 54.4% of non-intubated patients and 91.5% of intubated patients.

Toothbrushes are more effective than foam swabs in plaque removal and gingival stimulation and are generally regarded as the best tool for mechanical oral care in healthy populations. However, noted that even in healthy populations, the effectiveness of toothbrushes depends on use of the devices in a proper fashion for a sufficient duration of time and with adequate frequency. Toothbrushes are less commonly used than foam swabs in providing mouth care to hospitalized patients. In surveys, ICU nurses reported only a 38.9% frequency for use of a toothbrush to provide oral care to intubated patients.

Little information is available on mechanical reduction in oral microbial flora via tooth brushing in critically ill adults. In an interventional study to show the importance of oral nursing care in the ICU, the oral care needs of patients receiving mechanical ventilation were not specifically addressed; rather an oral care protocol for maintenance of oral mucosal integrity in all ICU patients was tested. Compared with usual care, nurse-administered oral care via a defined protocol with a soft pediatric toothbrush and nonprescription products enhanced removal of plaque in critically ill adults. The relationship of the intervention to quantity and type of oropharyngeal flora or to development of VAP was not examined. In a more recent study, compared the condition of the mucous membranes, tongues, and teeth of 8 ICU subjects before tooth brushing with that of 8 different subjects after tooth brushing. Stiefel et al noted improvements in the condition of the mucous membranes and teeth in the group who received tooth brushing, although dental plaque and microbial flora were not quantified and systemic outcomes such as development of VAP or bacteremia were not examined.

Additional research to fully understand the effects of mechanical interventions is essential, because theoretically these interventions are not without risk.
Because mechanical interventions disrupt the adherence of microorganisms to the oral cavity but are not microbicidal, they might increase translocation of organisms from the oral cavity to the trachea or bloodstream if the organisms are not efficiently removed from the oral cavity. Studies to determine the best methods and frequency of care are also needed.

**Pharmacological Interventions**

Pharmacological oral care involves control of plaque via removal of oral microorganisms by oral topical administration of bactericidal agents. Pharmacological methods also have a long history of efficacy in healthy populations. Use of oral topical antibiotics directed against gram-negative organisms can reduce the incidence of VAP related to those pathogens. Abele-Horn et al studied the effects of tobramycin administered as an oral topical agent in patients receiving mechanical ventilation; 58 of 88 patients were treated with the antibiotic; the other 30 were not. Treatment with the antibiotic reduced the incidence of VAP due to gram-negative pathogens. Although development of resistant organisms was not observed, overgrowth of *S. aureus* (a gram-positive microbe that can cause VAP) in the oropharynx occurred in patients given tobramycin.

Pugin et al evaluated selective decontamination of the oropharynx with a mixture of polymyxin B sulfate, neomycin sulfate, and vancomycin hydrochloride in a double-blind, placebo-controlled trial of 52 patients receiving mechanical ventilation. Tracheobronchial colonization by microorganisms that can cause VAP and pneumonia occurred less often in patients treated with the antibiotics than in patients treated with a placebo (*P* < .001), although mortality was not affected.

These studies support the hypothesis that VAP can be reduced by pharmacological oral intervention, but the antibiotics used in the studies are not ideal. Although emergence of antibiotic resistance did not occur in these studies, antimicrobial resistance has been reported for the agents used and remains a theoretical risk.

Chlorhexidine is a broad-spectrum antibacterial agent used extensively in healthy populations as an oral rinse to control plaque and to prevent and treat gingivitis. Microbial resistance to chlorhexidine has never been demonstrated, and administration by oral rinse has not been associated with serious side effects, making it an attractive alternative to the oral topical antibiotics used in the studies discussed earlier. Chlorhexidine is bactericidal for both gram-positive and gram-negative species. It is not absorbed through skin or mucous membranes, so dosage adjustments are not necessary for patients with renal or hepatic insufficiency. Serious allergic reactions to the oral rinse are extremely rare. Reported side effects include discoloration of the teeth and tongue and transient alterations in taste (dulling of taste sensation for several hours). Discoloration of the teeth occurs in about 50% of patients with long-term administration and is similar to tooth staining associated with smoking tobacco or consuming drinks containing tannic acids, such as tea, coffee, and wine. Chlorhexidine discoloration is easily removed by professional dental hygienists.

The effectiveness of oral chlorhexidine in reducing nosocomial respiratory tract infections in patients having elective cardiac surgery was examined in 2 studies. No investigators have addressed the effects of chlorhexidine in reducing VAP in other critically ill populations. DeRiso et al conducted a double-blinded, placebo-controlled study of chlorhexidine in patients who had elective cardiac surgery. Houston et al did a similar randomized placebo-controlled study in cardiac surgery patients.

In healthy populations, chlorhexidine is self-administered as a 15-mL oral rinse with a 0.12% solution twice daily. In the studies by DeRiso et al and Houston et al, patients were randomly assigned to receive chlorhexidine or placebo; the interventions were begun preoperatively (self-administered oral rinse) and continued throughout the ICU stay (swabbed over the entire oropharynx by staff nurses). In the study by DeRiso et al, the rate of respiratory tract infection was lower in patients who received chlorhexidine than in those who received placebo (17 of 180 patients vs 5 of 173 patients; *P* < .05). In the study by Houston et al, the number of patients who had nosocomial pneumonia was lower in patients who received chlorhexidine than in patients who received placebo (4 of 270 patients vs 9 of 291 patients; *P* = .21), but the results were statistically significant only for the subset of patients who retrospectively were at highest risk for pneumonia (intubated >24 hours, with sputum cultures showing the most growth; 2 of 10 patients given chlorhexidine vs 7 of 10 patients given placebo; *P* = .02).

However, application of these findings to other ICU settings is limited by several factors. First, patients admitted for elective cardiac surgery are likely to have different comorbid conditions and better physiological status at the time of intubation than are patients intubated emergently. This difference is reflected in the relatively low incidence of respiratory tract infections noted in patients given placebo (9% in the study by DeRiso et al and 3% in the study by...
remains to be elucidated as well. Other systemic complications, such as bacteremia, have not been adequately tested. The role of oral health in critically ill adults receiving mechanical ventilation has not been independently studied; combination interventions (ie, mechanical plus pharmacological) have not been studied. Yet, combination interventions might have interactive effects that would enhance removal of dental plaque and oral microbial flora. The physiological processes underlying the interventions provide support for this notion. For example, because oral organisms live in a complex biofilm, pharmacological killing of adherent organisms might decrease the adherence of any remaining organisms, making the remaining microbes more susceptible to removal by mechanical means. Conversely, physically reducing the number of organisms through mechanical means such as tooth brushing might enhance the effectiveness of a bactericidal agent on the remaining organisms.

Combination Intervention
Research on the effect of either mechanical or pharmacological oral care interventions used independently is limited; combination interventions (ie, mechanical plus pharmacological) have not been studied. Yet, combination interventions might have interactive effects that would enhance removal of dental plaque and oral microbial flora. The physiological processes underlying the interventions provide support for this notion. For example, because oral organisms live in a complex biofilm, pharmacological killing of adherent organisms might decrease the adherence of any remaining organisms, making the remaining microbes more susceptible to removal by mechanical means. Conversely, physically reducing the number of organisms through mechanical means such as tooth brushing might enhance the effectiveness of a bactericidal agent on the remaining organisms.

Oral care interventions currently used in critically ill patients are not evidence based.

Summary and Implications for Practice
Oral health, which includes the components of oral immunity, oral microbial flora, and dental plaque, contributes to the general health of critically ill patients and may have a role in preventing VAP. Theoretical support exists for a defined oral care intervention to improve oral health and thereby reduce the occurrence of VAP. However, the effect of oral care interventions on dental plaque, oral immunity, oral microbial flora, and the development of VAP in critically ill adults receiving mechanical ventilation has not been adequately tested. The role of oral health in other systemic complications, such as bacteremia, remains to be elucidated as well.

Mechanical oral care involves removal of plaque by tooth brushing and/or rinsing of the oral cavity. Mechanical methods have a long history of efficacy in healthy populations. Chlorhexidine was effective in reducing respiratory infections in patients undergoing elective cardiac surgery when administration was begun preoperatively. However, currently, no extensively tested evidence-based oral care protocols for the general critical care population are available, and none of the existing research provides clear guidance regarding nursing care. The most recent Centers for Disease Control and Prevention recommendations for prevention of nosocomial bacterial pneumonia in patients receiving mechanical ventilation do not specifically address strategies to reduce oral microbial flora.

Oral care interventions have great potential to improve oral health, reduce the occurrence of VAP, and influence other systemic complications such as bacteremia. The association between potentially pathogenic oral microbial flora and VAP is well documented, but no studies have compared oral care methods in patients receiving mechanical ventilation to determine the most effective procedures for removal of microorganisms or reduction of VAP. Because endotracheal tubes must traverse the contaminated oral cavity during intubation, and the presence of an endotracheal tube provides a continuous route for oral bacteria to move into the lung, an intervention to reduce the oral microbial flora as early as possible is theoretically attractive as a means to reduce the development of VAP.

Routine oral care is a low priority throughout the ICU stay and is therefore unlikely to be addressed during the initial hours to days of critical illness when changes in the oral environment occur and risk of colonization with organisms that can cause VAP is high. We and our colleagues are currently conducting a randomized clinical trial to determine the efficacy of mechanical, pharmacological, and combined (mechanical and pharmacological) longitudinal oral care interventions after intubation in reducing VAP in a variety of critically ill patients. Additional research is needed to determine optimal frequency, procedures, and materials for oral care interventions in critically ill patients and to document the impact of oral care provided by nurses on patients’ outcomes.

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REFERENCES
In a journal club, research articles are reviewed and critiqued. General and specific questions help to aid journal club participants in probing the quality of the research study, the appropriateness of the study design and methods, the validity of the conclusions, and the implications for practice.

When critically appraising this issue’s AJCC journal club article, *Oral Health and Care in the Intensive Care Unit: State of the Science,* consider the questions and discussion points listed below.

**Study Synopsis: This article presents a review and critique of the literature on oral health and oral care practices for the critically ill.** The concepts of oral immunity, bacterial colonization, and factors that increase bacterial colonization during critical illness are discussed. Colonization of the oral pharynx has been demonstrated to increase the incidence of ventilator-associated pneumonia (VAP) in the critically ill, which further complicates recovery from critical illness. Traditional nursing care measures, such as use of oral swabs or toothettes for oral care, are not effective at removing dental plaque and associated microbes that can contribute to bacterial colonization. Studies examining the effectiveness of tooth brushing have demonstrated beneficial results; however, there has been limited research in this area. Additional research is necessary to generate the data needed to formulate evidence-based oral care practices that promote oral health in the critically ill.

**A. Description of the Study**
- What were the purposes of this review?
- Why is the problem significant to nursing?
- What factors increase bacterial colonization of the oropharynx in patients receiving mechanical ventilation?

**B. Literature Evaluation**
- Evaluate the research cited in the literature review.
- Discuss the types of studies that have examined oral care practices.
- Discuss studies that have examined mechanical oral care interventions.
- Discuss studies that have examined pharmacological oral care interventions.

**C. Conclusions**
- What are the conclusions of this review?

**D. Clinical Significance**
- What are implications for clinical nursing?
- What are specific areas for additional research?

**Information From the Authors:** Cindy Munro, PhD, RN, ANP, co-author of this journal club article, provided additional information about the importance of oral care practices in the intensive care unit (ICU). She explains, “Stress affects both innate and acquired immune mechanisms. It is likely that the stress of being critically ill changes the person’s innate oral immunity. Changes in saliva also will contribute to changes in innate immunity in the oral cavity; these changes may be related to the mouth being continuously open (because of tubes traversing the mouth), the inability to take fluids orally, and the patient’s hydration status.”

Oral care for patients receiving mechanical ventilation is especially important, as bacterial colonization can lead to VAP. Munro explains, “The dental plaque in the mouth of critically ill persons is a very likely source for VAP pathogens, which highlights the importance of oral care interventions that remove plaque. We have found that VAP pathogens can be cultured from the mouth of patients who develop VAP prior to or concurrently with the same organism being cultured from endotracheal secretions.”

Munro describes the state of the science on oral care as one that is developing: “The science is in its beginning phases. Research has not yet provided clear evidence of safe and effective practices. However, there is a great deal of interest in building the evidence base for oral care, and research in this area is active.”

**Implications for Practice:** Munro identifies that nurses play a key role in helping to promote best practices for oral care. She relates, “Removing dental plaque must be an essential goal of oral care, and there is good evidence in populations other than the critically ill that a toothbrush is effective in plaque removal. We receive many communications from nurses who are trying to develop evidence-based oral care protocols for their ICUs, but there is not a strong research base to guide practice yet. While it is important for nurses not to label care as “evidence based” until there really is research to support particular practices, I support the development of standardized protocols for oral care (using guidance available from professional dental societies and research in other populations) while the best practices in critically ill patients are being discovered. In addition, it is also important for nurses to document current oral care practices.”

**Implications for Research:** While additional research is needed in many areas pertaining to oral care practices, Munro identifies some priority areas: “Studies that compare products in ICU patients in terms of plaque removal effectiveness, cost, nursing time, and ease of use are needed.” Current research studies being conducted by Munro and co-author Grap are aimed at exploring oral care interventions (tooth brushing alone and in combination with chlorhexidine) that reduce risk of VAP. Munro relates, “Dr Mary Jo Grap and I have a long-standing research collaboration that builds on her strength in optimizing the pulmonary function of patients receiving mechanical ventilation and my strength in oral microbiology and immunology. We have a strong research team that includes project supervisors, research nurses, research assistants, physicians, biomedical engineers, biostatistians, and data managers. We are actively involved in research in this area, and currently have 2 federally funded projects examining oral interventions to reduce VAP risk.” Munro and Grap’s research will provide important information on the effect of specific oral care regimens on oral health and VAP that will improve outcomes for critically ill patients. Their research will help to advance the state of the science of oral care for critically ill patients.

*Journal Club feature commentary is provided by Ruth Kleinpell.*
Oral Health and Care in the Intensive Care Unit: State of the Science
Cindy L. Munro and Mary Jo Grap

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